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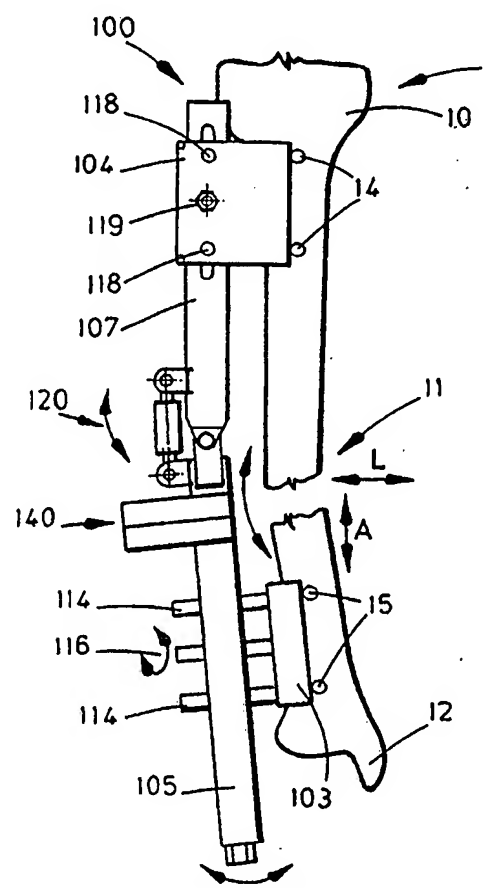
(57) Abstract

A fracture reduction device comprises linear adjustment means for linearly reducing a fractured bone in three directions, and angular adjustment means for angularly reducing a fractured bone about three independent axes. The adjustment means are such that adjustment in each direction and about each axis is independent of the others. The device also allows stable incremental adjustments to be made to the bone position and/or orientation.



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FRACTURE REDUCTION DEVICE

The present invention relates to fracture reduction devices.

A variety of techniques are known for holding together the parts of a fractured bone while healing takes place. One such technique is external fixation, in which pins are inserted into the bone on each side of the fracture point, and which are then connected to a frame by adjustable clamps. The clamps can then be tightened to hold the parts of the bone fixed with respect to each other.

However, before such fixation can take place, the fracture must be reduced so that the bone fragments are in the correct positions for fixation and healing.

Previously considered reduction devices allow such reduction to be controlled, but are inconvenient since it is not simple to control a single degree of freedom of movement independently of the other degrees of freedom.

Thus it is desirable to provide a fracture reduction apparatus in which the bone fragments can be moved in all six degrees of freedom (three distractive and three rotative), each degree of freedom being independently adjustable.

It is also desirable to provide a fracture reduction apparatus in which controlled vector separation can be easily and simply achieved.

According to a first aspect of the present invention, there is provided a fracture reduction device comprising linear adjustment means for linearly reducing a fractured bone in three directions, and angular adjustment means for angularly reducing a fractured bone about three independent axes, the adjustment means being such that adjustment in each direction and about each axis is independent of the others.

The linear directions are preferably mutually perpendicular, and the three axes are also preferably mutually perpendicular.

An embodiment of the first aspect of the present invention can provide a fracture reduction apparatus for attachment between respective bone pins inserted into fractured bone fragments, the apparatus comprising longitudinal adjustment means for adjusting the longitudinal separation of the bone pins, lateral adjustment means for varying the lateral spacing of the bone pins in two further directions and angular

adjustment means for varying the relative rotation of the bone pins about three axes, the adjustment of each such parameter being independent of the others.

According to a second aspect of the present invention, there is provided a fracture reduction device comprising linear adjustment means and angular adjustment means for reducing a fractured bone, the adjustment means allowing stable incremental adjustments to be made to the bone position and/or orientation.

One embodiment of the invention provides a fracture reduction device, comprising:

a first element and a second element;

a first support, for mounting to a first bone fragment, the first support being connectable to the first element, with the position thereof being adjustable in two perpendicular directions; and

a second support, for mounting to a second bone fragment, the second support being connectable to the second element, with the position thereof being adjustable in first and second mutually perpendicular directions;

the first and second elements being connected together at a joint that allows relative rotation of the supports about first and second mutually perpendicular axes,

one of the first and second supports being connectable to the respective element with the position thereof being adjustable in a third direction perpendicular to the first and second directions; and

one of the first and second supports being connectable to the respective element with the orientation thereof being adjustable about a third axis perpendicular to the first and second axes.

A preferred embodiment of the invention provides a fracture reduction device for attachment to a fractured bone, the device comprising:

a substantially rigid support structure;

first and second loading supports attached to the support structure for attachment to a fractured limb, the loading supports being arranged such that the limb can be subjected to a longitudinal force by means of the loading supports; and

first and second bone supports for attachment to a fractured bone about a fractured site,

one of the first and second loading supports being rotatable with respect to the other loading support about two mutually perpendicular axes, and

one of the first and second bone supports being movable in two linear directions perpendicular to the longitudinal direction of the bone.

The provision of adjustment means which allow incremental adjustment to be made enables a fractured bone to undergo gradual vector separation in order to improve the healing process. Such incremental adjusters are preferably screw-threaded, but could be provided by some suitable alternative.

Once reduction is complete, a bone fixator may be fitted and the reduction device removed.

For a better understanding of the invention, and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:-

Figure 1 shows a schematic view of a first embodiment of the present invention applied to a fractured bone;

Figure 2 shows an enlarged view of a distal part of the embodiment of Figure 1;

Figure 3 shows an enlarged view of a proximal part of the Figure 1 embodiment;

Figure 4 shows an enlarged view of a first angular adjuster of the Figure 1 embodiment;

Figure 5 shows an enlarged view of a third part of the embodiment of Figure 1;

Figure 6 shows a schematic view of a second embodiment of the present invention, applied to a fractured leg;

Figure 7 shows an enlarged view of part of the embodiment of Figure 6;

Figure 8 shows an enlarged view of another part of the Figure 6 embodiment;

Figure 9 shows an enlarged view of yet another part of the Figure 6 embodiment;

Figure 10 shows an enlarged view of a further part of a Figure 6 embodiment;

Figure 11 shows an engineering drawing of a practical embodiment of the Figure 1 design;

Figure 12 shows an enlarged view of part of the embodiment of Figure 11;

Figure 13 shows an enlarged view of another part of the embodiment of Figure 11; and

Figure 14 shows an enlarged view of a further part of the Figure 11 embodiment.

Figure 1 shows a fracture reduction device 100 attached to a fractured bone 1 in this case a tibia. The fractured bone 1 includes a proximal bone fragment 10 and a distal bone fragment 12. The bone has been fractured at a fracture site 11. Bone pins or screws 14 and 15 are inserted into the bone fragments 10 and 12 as shown in Figure 1. The pins are preferably uni-cortical bone screws which are inserted using normal clinical methods. Use of the uni-cortical bone screws allows later use of conventional intra-medullary nailing. Such a device is used in an operating theatre to achieve anatomical reduction of fractured long bones, in the case of Figure 1 a tibia, but this use could be extended to other bones and is by no means restrictive.

The reduction device 100 is attached to the bone pins 14 and 15 by way of support blocks 103 and 104.

The device 100 comprises a distal support tube 105 attached by means of angular adjusters 120 and 140 to a proximal support tube 107. An adjustment block (see Figure 2) which is located inside the distal support tube 105 is attached to the distal support block 103 by means of lateral adjustment pins 114. A lateral (in the direction L) adjustment screw 116 extends from the distal support block 103 through the adjustment block 101.

The proximal support tube 107 is attached to the proximal bone pins 14 by means of the proximal support block 104, and adjustment block (see Figure 3) inside the support tube 107 is attached to the block 104 by means of pins 118 and adjustment

screw 119. The pins 118 and adjustment screw 119 extend in a direction perpendicular to the page of the figure.

The reduction device would generally be used in the following manner. The fractured bone is subjected to a distractive force (longitudinal force) to provide primary reduction. This force is opposed by the muscle and surrounding tissue which tends to reduce the bone. Such reduction is not stable, nor perfect. The reduction device is then attached to the bone pins so that accurate reduction of the fracture can be performed. In normal circumstances, the longitudinal and lateral adjustments would be made first followed by angular adjustments. This technique obviously depends upon the specific circumstances encountered, however. One adequate reduction has been achieved, then the bone can be fixed by applying any type of fracture fixation device to retain the bone in its reduced state during the healing process.

The specific structures of the various adjustment mechanisms will now be described with reference to Figures 2, 3 and 4.

Figure 2 shows an enlarged view of the distal bone fragment 12, into which two uni-cortical bone pins 15 are fixed. The distal mounting block 103 comprises a pair of blocks 1031 and 1032 which are clamped to either side of the bone pins 15. The distal support block 103 can thus provide a rigid mounting block for the distal end of the reduction device 100. A pair of lateral adjustment pins 114 and a lateral adjustment screw 116 extend from the block 1031.

The distal support tube 105 includes an adjustment block 101 which is slidable on the lateral adjustment pins 114 and which has a threaded portion 117 for engagement with the adjustment screw 116.

In order to adjust the lateral position of the distal bone fragment 12 with respect to the reduction device 100, the head 118 of the lateral adjustment screw 116 is turned, so that the adjustment block 101 is caused to slide along the lateral adjustment pins 114 by virtue of the threaded engagement between the adjustment screw 116 and the block 101. Such movement may be referred to as coronal translation, and is indicated by arrow L in Figure 1.

The adjustment block 101 is also slidable longitudinally within the proximal support tube 105. To allow the black 101 to slide, the pins 114 and the adjustment screw 116 extend through elongate slots 108 in each side of the support tube 105.

An axial adjustment screw 109 engages with an axial adjustment nut 110 and extends to be fixed to the block 101. The adjustment nut 110 is attached to the distal end of the support tube 105, so that rotation of the adjustment screw 109 causes the screw to move longitudinally with respect to the tube. Such longitudinal movement of the adjustment screw 109 causes the block 101 to move longitudinally along the tube 105. Thus, the axial (longitudinal) position of the bone fragment 10 can be adjusted with respect to the device. The device can thereby subject the bone to traction.

Figure 3 shows an enlarged view of the proximal end of the device 100. A support block 104 is clamped, using parts 1041 and 1042 to the pair of bone pins 14 in the proximal bone fragment 10. Vertical (in the direction V of Figure 3 with respect to the bone) adjustment pins 118 extend from the part 1041, as does a vertical adjustment screw 119. The proximal support tube 107 defines a slot through which the pins 188 and screw 119 extend. Inside the proximal support tube 107 there is located an adjustment 106 which is similar to that shown in Figure 1 (101). The adjustment block 106 is able to slide freely on the pins 118 and adjustment screw 119.

The axial position (longitudinal position) of the distal support tube 107 is fixed by locking the locking nut 19a against the tube 1077 depending on the length of the bone fragment 10. The relative vertical positions (as shown in Figure 3) of the bone fragment 10 and the support tube 107 can be adjusted by rotating the adjustment nut 119b. The threaded engagement with the adjustment screw 119 means that such turning of the nut 119a results in vertical movement of the tube 107.

Figure 4 shows an enlarged view of the first angular adjuster 120 of the Figure 1 device, which attaches between the ends of the distal and proximal support tubes 105 and 107. As can be clearly seen from Figure 3, the adjuster 120 comprises two pivot blocks 121 and 122 which support respective pivots 121a and 122a. The axes of the pivots 121a and 122a are mutually perpendicular, and are both perpendicular to

the longitudinal axis of the device. A connecting part 123 connects the pivot black 121 with the pivot block 122, and is rotatable about both pivots 121a and 122a.

The pivot blocks are connected by a pair of turnbuckle arrangements 125 and 130 which enable adjustment and restriction of the angular movement between the two pivot blocks 121 and 122. Two turnbuckle arrangements 125 and 130 are provided in order to provide adjustment of rotation about both axes 121a and 122a. The arrangement 125 will be described in detail, but it will be appreciated that the arrangement 130 is of identical construction, but is attached to different faces of the pivot blocks 121 and 122.

The turnbuckle arrangement 125 comprises two pivot blocks 126 which support respective pivot axes 126a and 126b. A first threaded member 127 is supported for rotational movement from the pivot axis 126a, and a second threaded member 128 is supported for rotational movement about axis 126b. The threaded portions 127 and 128 are connected by a turnbuckle block 129. The threaded portions 127 and 128 have oppositely oriented threads such that rotation of the turnbuckle portion 129 causes the threaded parts 127 and 128 to undergo relative movement towards or away from one another. As an alternative, the threaded part 127 could be replaced by a simple swivel.

Rotation of turnbuckle block 129 causes the first pivot block 121 to rotate relative to the second pivot block 122 and the axis 121a. Similarly, rotation of the turnbuckle block of the second arrangement 130 causes relative rotation of the pivot blocks about the axis 122a.

Rotation of the turnbuckle part 129 enables the relative angular displacement of the two support tubes 105 and 107 to be adjusted. The provision of two turnbuckle arrangements 125 and 130 allows rotation about both axes 121a and 122a to be controlled independently of one another. Such angular adjustment of the tubes 105 and 107 causes angular movement of the bone fragments 10 and 12 about the fracture site 11.

The axial displacement of the proximal support tube 107 is adjusted so that the angular adjuster 120 (and the angular adjuster 140) are located approximately adjacent the fracture site 11.

Figure 5 shows an enlarged view of the second angular adjuster 140 which is located along the distal support tube 105, thereby effectively splitting the support tube 105 into two portions, as is readily apparent from Figure 5.

The angular adjuster 140 comprises a first approximately sector shaped block 141 attached to one part of the support tube 105 and a second larger approximately sector shaped block 142 attached to the other portion of the support tube 105. The first and second blocks are held together by adjustment bolts 143 which extend through circular holes in the first block 141 and through an arcuate slot 144 in the second block 142. Thus, slackening of the bolts 143 allows relative rotation of one block with respect to the other. The adjustment bolts 143 are tightened when the required angular position is obtained. In this way, the bone fragments 10 and 12 can be rotated with respect to one another about a longitudinal axis.

The first embodiment of the present invention thus provides a reduction device in which six degrees of freedom (three distractive and three rotational) can be adjusted independently of one another.

Figure 6 shows a schematic diagram of a second embodiment of the present invention applied to a fractured leg bone 1 having a fracture site 11 and proximal and distal bone fragments 10 and 12. The device 200 is attached to a patient using two rods 227 and 243. The first (proximal) rod 227 passes through the leg at or about the knee and the second (distal) 243 passes through the leg at or around the ankle. These rods allow a tensile force to be applied to the broken bone 10.

Two bone pins 14 and 15 are attached close to the fracture site 11, the bone pins are generally uni-cortical as before, and the reduction device 200 is attached to the bone pins.

The device 200 is used in a similar manner to the first embodiment, except that the initial distractive (longitudinal) force can be applied directly using the device 200

of Figure 6. The reduction process can then take place before the bone is fixed using a fixation device.

The device 200 comprises two support tubes 225 which extend parallel to the leg bone 1 and which extend from a proximal end fixing arrangement 220 to a distal end fixing arrangement 230. The proximal end fixing arrangement 220 comprises a substantially C-shaped bracket 221 having clamp regions 223 to which the support tubes 225 are rigidly attached. The proximal end rod 227 is held in slots 228 in the bracket 221. The side support tubes extend to a distal end bracket 223 and are rigidly clamped thereto by clamps 234.

A mounting plate 231 is slidably mounted on the tubes 225 and carries a distal end attachment 240, which will be described in more detail below. The attachment 240 holds the distal end support rod 243 which passes through the distal end of the bone.

Bone pin brackets 201 are slidably engaged on one of the support tubes 225 as shown in Figure 6, and will now be described with reference to Figure 7.

Each bone pin bracket 201 is adjusted for longitudinal position and then clamped to the side tube 225. Bone pins 14 and 15 are inserted into respective bone fragments 10 and 12 and have their position, and hence the fracture position, controlled by the device 200 via the brackets 201. Each bracket includes a main bracket body 202 which clamps to the side tube when in use, and which defines a slot 203. An adjustment block 205 is arranged to engage with the slot 203 and thereby be slidable along the main body 202. A flange 204 extends from the body 202 and supports an adjustment screw 206. The adjustment screw 206 engages with the block 205 so that the position of the block can be controlled and adjusted as required by turning of the screw 206.

A plate 208, which defines a slot 209, is carried on the block 205 by means of a fixing screw 213. A flange 210 extends from the plate 208 and is secured thereto by a screw 214. The flange 210 supports a second adjustment screw 212, which engages with the block 205. The plate 208 carries the bone pin 14, 15.

Adjustment of the bone pin position is achieved by rotating the adjustment screws 206 and 212. Rotating screw 206 moves the pin in a vertical direction shown by arrow A (up/down) which is the sagittal direction, and rotating the adjustment screw, 212 moves the pin in a lateral direction shown by arrow B (the coronal translation).

The bone pin brackets allow the two directions of adjustment to be adjusted independently of one another and without causing unwanted uncontrolled movement at the fracture site 11.

Figure 8 shows an enlarged view of the second end fixing system 240. A mounting plate 231 is slidably engaged with the side support tube 225 and carries a support block 244. In turn, the support block 244 carries three rollers 246 and 247. A substantially C-shaped bracket 241 is slidably engaged with these rollers. The bracket 241 carries the distal fixing rod 243 in slots 242. The rod 243 passes through a distal part of the leg.

Sliding the C-shaped bracket 241 through the rollers 246 and 247, enables the angular displacement of the leg to be adjusted in the coronal plane (i.e. about an axis perpendicular to the longitudinal and lateral/coronal directions). The movement of the bracket 241 can be controlled by frictional engagement with the rollers 246 and 247, or by a fixing screw (not shown).

Figure 9 shows a cross-sectional view of further details of the distal fixing arrangement 240. The support block 244 is held on the mounting plate 231 by means of a nut 248 and bolt 249 arrangement. When the nut 248 is slackened, the support block 244 is able to rotate about the longitudinal axis of the device, thereby enabling the angular position of the leg, and the distal bone fragment 12 to be adjusted with respect to the proximal bone fragment 10. When the required angular displacement is achieved, the nut 248 can be locked thereby fixing the relative positions.

Figure 10 shows a view of the further details of the fixing arrangement 240. A support plate 233 is rigidly attached to the support bars 225 by means of clamps 234. This provides a rigid reference point for longitudinal movement of the device. A threaded adjustment screw 2235 extends from the sliding support plate and is in

threaded engagement with the fixed support plate 234. A handle 236 is rigidly attached to the free end of the adjustment screw 235, so that rotation of the handle causes the screw 235 to rotate, thereby adjusting the position of the sliding support plate 231 by virtue of the threaded engagement between the screw and the rigid support plate.

The arrangement shown in Figure 10 allows longitudinal extension (traction) to be applied to the leg by simply turning the screw 235. Such adjustment is independent of the other position adjustments.

Figures 11, 12, 13 and 14 show detailed drawings of a practical device similar to the first embodiment described with reference to Figures 1 to 5, and hence a detailed description of the device will not be made here.

However, it can be seen that the device 300 includes a lateral adjuster 301, a vertical adjuster 302, and an axial adjuster 303. The device 300 also includes first angular adjuster 304 (including turnbuckle arrangement 305 and 306 as previously described) and a second angular adjuster 308.

Figure 12 shows an alternative arrangement for vertical and first angular adjustment.

As can be seen from Figure 12 vertical adjuster 302 is attached to bone pins 14 and includes a main block 3021 which defines a vertical slot 3022. A movable block 3024 is arranged to slide vertically in the slot 3022, its position being controlled and held by an adjustment bolt 3023.

The Figure 12 components also provide an angular adjuster 408 having a body portion 4081 about which a block 4083 is able to rotate by means of a nut and bolt arrangement 4082.

A longitudinal adjuster 403 is provided by a threaded bold 4031 and a threaded block 4032.

Figure 13 shows an alternative vertical adjuster 402 comprising a block 4021 defining a slot 4022 in which an adjustment 4023 is slidable.

An angular adjuster 404 is provided by a block 4041 about which a part 4042 can rotate by means of a pin or nut and bolt (not shown). The amount of movement of the part 4042 is limited by a pin engaging with a slot on the body 4041.

An alternative longitudinal adjustment arrangement 413 is shown in Figure 13, and includes a threaded elongate member 4134 which engages with an adjustment nut 4133. A guide part 4132 engages with part of the support tube 4131 and includes a spigot which engages with a keyway in the elongate part 4134 so as to prevent unwanted rotation of the part 4134.

Longitudinal adjustment of the device is achieved by rotating the nut 4133 thereby causing the elongate part to move longitudinally.

The guide portions 4132 can be rotated about the support tube 4131, thereby providing angular adjustment about the longitudinal axis.

Figure 14 shows a further alternative arrangement for providing angular and linear adjustment, in a manner similar to that described with reference to Figures 12 and 13.

It will be appreciated that a device embodying the present invention allows independent adjustment to be made to the bone fragment positions in each of six degrees of freedom.

Furthermore, the embodiments described, particularly with reference to Figures 1 to 10, allow stable incremental adjustments (vector separation) to be made during the reduction process. In contrast, previously-considered reduction devices have required almost complete slackening of adjustment bolts etc. to enable adjustments to be made.

The embodiments of the invention include adjustment mechanisms which hold their position, even when undergoing adjustment.

One advantage of this design is that repeated separation/reduction of the fractured bone can be easily achieved. Simply turning the screw threaded adjusters enables such incremental adjustment.

Other major advantages of devices embodying the present invention are:

Repeatably better anatomical reduction, through the provision of independent adjusters;

Repeatably better operating times, up to 50% less than with conventional devices, achieved by virtue of the simple design;

Minimal interference at the fracture site. This enables easy access for X-ray or image intensifier equipment, for judging the reduction process, and for easier access for attaching a fixator; and

Since there are no bi-cortical pins used in the preferred embodiments, the device is suitable for use with intra-medullary nailing.

CLAIMS

1. A fracture reduction device comprising linear adjustment means for linearly reducing a fractured bone in three directions, and angular adjustment means for angularly reducing a fractured bone about three independent axes, the adjustment means enabling adjustment in each direction and about each axis independent of the others.

2. A fracture reduction device comprising linear adjustment means and angular adjustment means for reducing a fractured bone, the adjustment means allowing stable incremental adjustments to be made to the bone position and/or orientation.

3. A fracture reduction device comprising the features of claim 1 and claim 2.

4. A fracture reduction device according to claim 1 or claim 3, wherein the linear directions are mutually perpendicular.

5. A fracture reduction device according to claim 3 or claim 4, wherein the three axes are mutually perpendicular.

6. A fracture reduction device according to any preceding claim, comprising:

a substantially rigid support structure;

first and second loading supports attached to the support structure for attachment to first and second portions of a fractured limb about a fracture site, the loading supports being arranged such that the limb can be subjected to a longitudinal distractive force by means of the loading supports; and

first and second bone supports for supporting first and second portions of a fractured bone about the fracture site,

one of the first and second loading supports being rotatable with respect to the other loading support about two mutually perpendicular axes, and

at least one of the first and second bone supports being movable in two linear directions perpendicular to one another and to the longitudinal direction of the bone.

7. A fracture reduction device according to claim 6, wherein both of the first and second bone supports are movable in two linear directions perpendicular to one another and to the longitudinal direction of the bone.

8. A fracture reduction device according to claim 6 or claim 7, wherein the first and second bone supports support the first and second portions of the bone at locations immediately adjacent the fracture site.

9. A fracture reduction device according to any one of claims 6 to 8, wherein the first and second bone supports are attached to the limb by strapping or the like, or are attached directly to the bone portions by bone pins or the like.

10. A fracture reduction device according to any one of claims 6 to 9, wherein said rigid support comprises at least one elongate member extending in said longitudinal direction across the fracture site.

11. A fracture reduction device according to claim 10, wherein the support structure comprises two said elongate members positioned on opposing sides of the limb, the first and second loading supports being secured between said two elongate members.

12. A fracture reduction device according to any one of claims 6 to 11, wherein said rotatable one of the first and second loading supports is said first loading suppuration, and wherein said at least one movable one of the first and second bone supports said first bone support.

13. A fracture reduction device according to any one of claims 6 to 12, wherein said rotatable loading support comprises a substantially C shaped member having two arms located on opposite sides of the limb, the loading support being attached to the limb by way of an elongate member extending between said two arms and through the limb, the C shape member being supported between rollers which allow the C shaped member to rock back and forth enabling rotation of the limb about one of said axis.

14. A fracture reduction device according to claim 13, wherein the C shaped member and rollers are supported by a support member mounted to the support structure so as to be rotatable about said longitudinal axis.

15. A fracture reduction device according to any one of claims 6 to 14, wherein one of said loading supports is slidably mounted upon said support structure and means are provided for controllably moving the loading support along said longitudinal axis towards and away from the other loading support to produce said longitudinal force.

16. A fracture reduction device according to claim 15, wherein the movable loading support is the first loading support.

17. A fracture reduction device according to claim 1, wherein the apparatus is adapted for attachment between respective bone pins inserted into fractured bone fragments, the apparatus comprising longitudinal adjustment means for adjusting the longitudinal separation of the bone pins, lateral adjustment means for varying the lateral spacing of the bone pins in two further directions and angular adjustment means for varying the relative rotation of the bone pins about three axes, the adjustment of each such parameter being independent of the others.

18. A fracture reduction device according any preceding claim, comprising:

a first element and a second element;

a first support, for mounting to a first bone fragment, the first support being connectable to the first element, with the position thereof being adjustable in two perpendicular directions; and

a second support, for mounting to a second bone fragment, the second support being connectable to the second element, with the position thereof being adjustable in first and second mutually perpendicular directions;

the first and second elements being connected together at a joint that allows relative rotation of the supports about first and second mutually perpendicular axes,

one of the first and second supports being connectable to the respective element with the position thereof being adjustable in a third direction perpendicular to the first and second directions; and

one of the first and second supports being connectable to the respective element with the orientation thereof being adjustable about a third axis perpendicular to the first and second axes.

19. A fracture reduction device according to any preceding claim, wherein the incremental adjusters are screw-threaded.

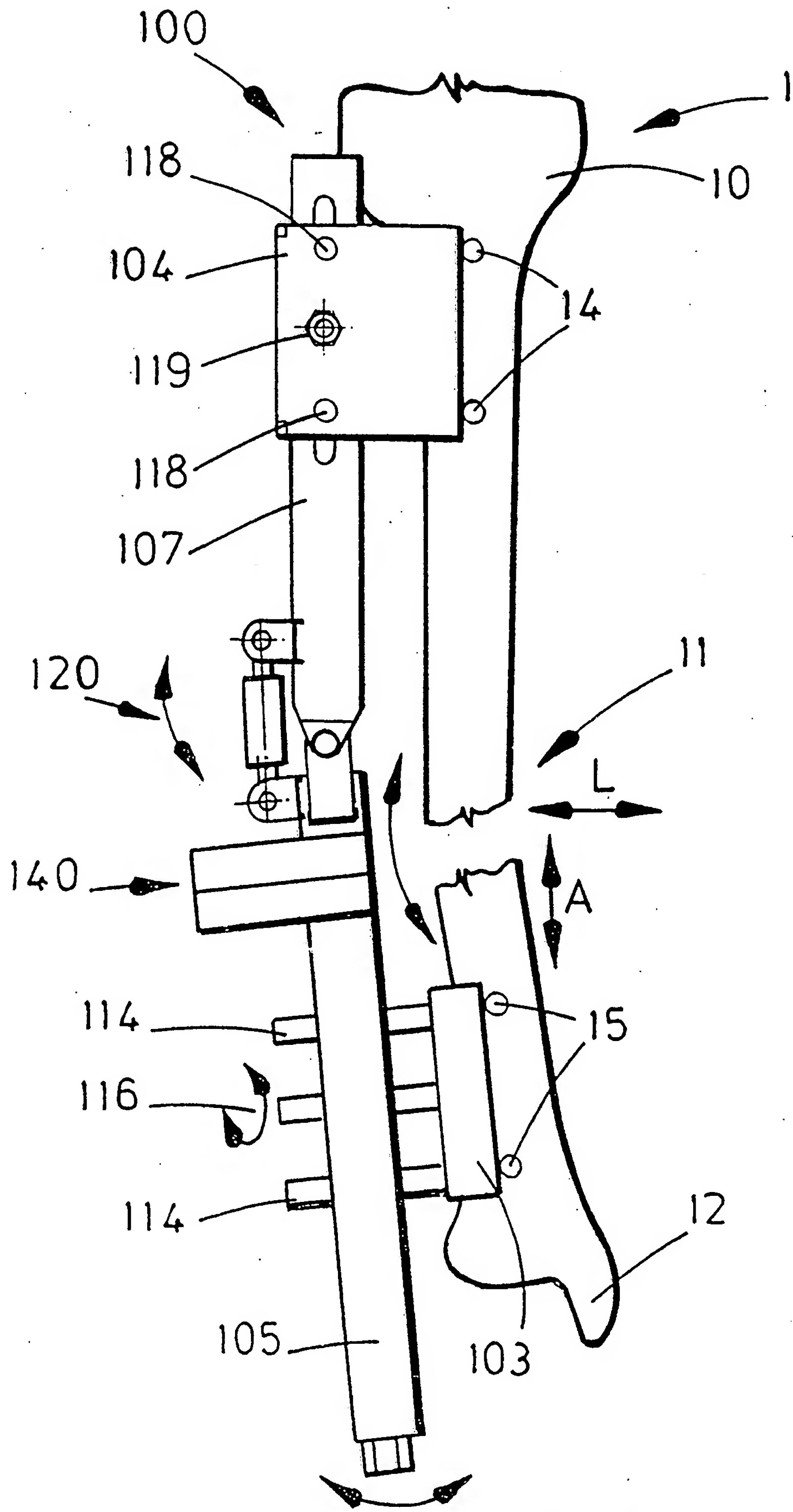
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FIG.1

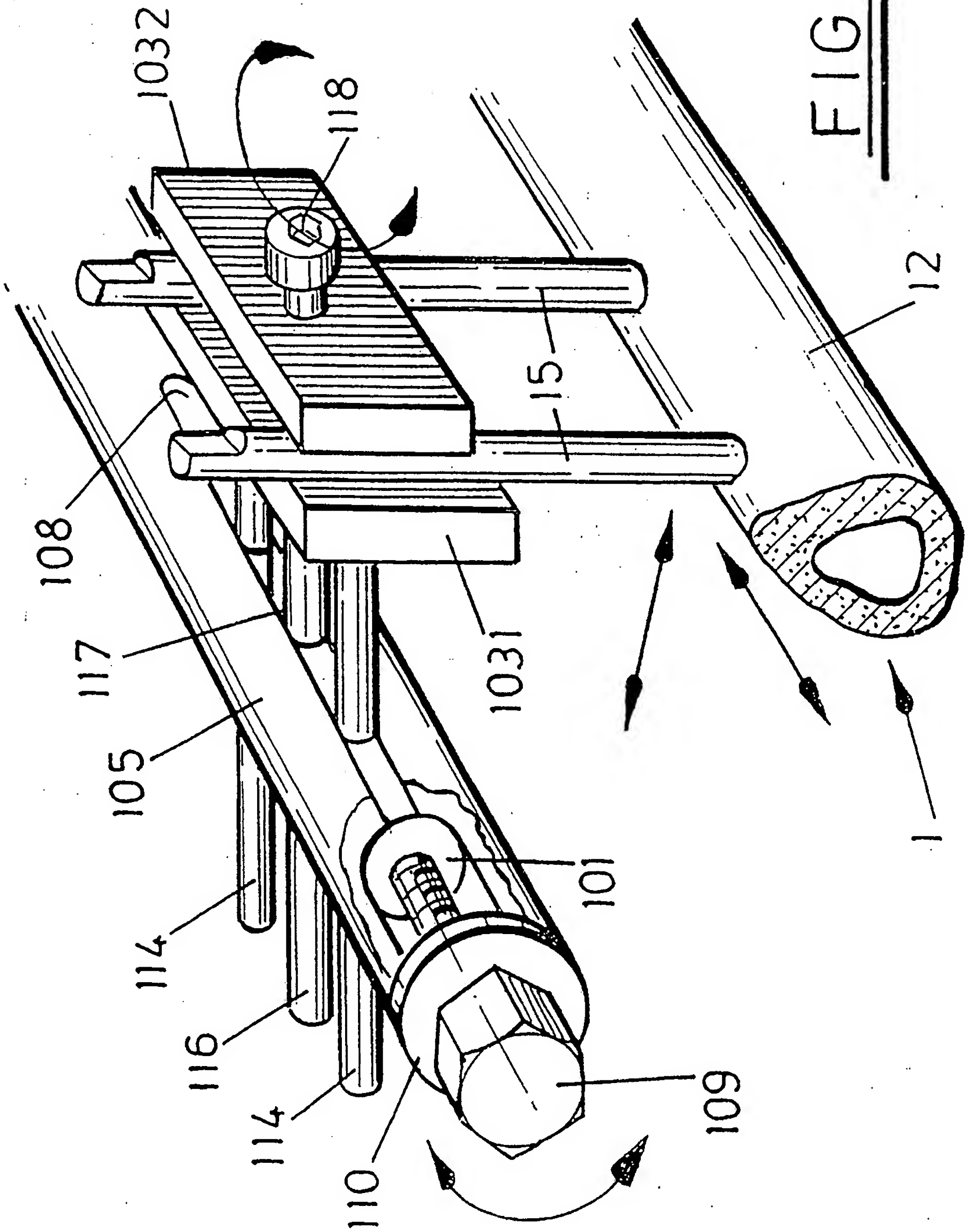


FIG. 2

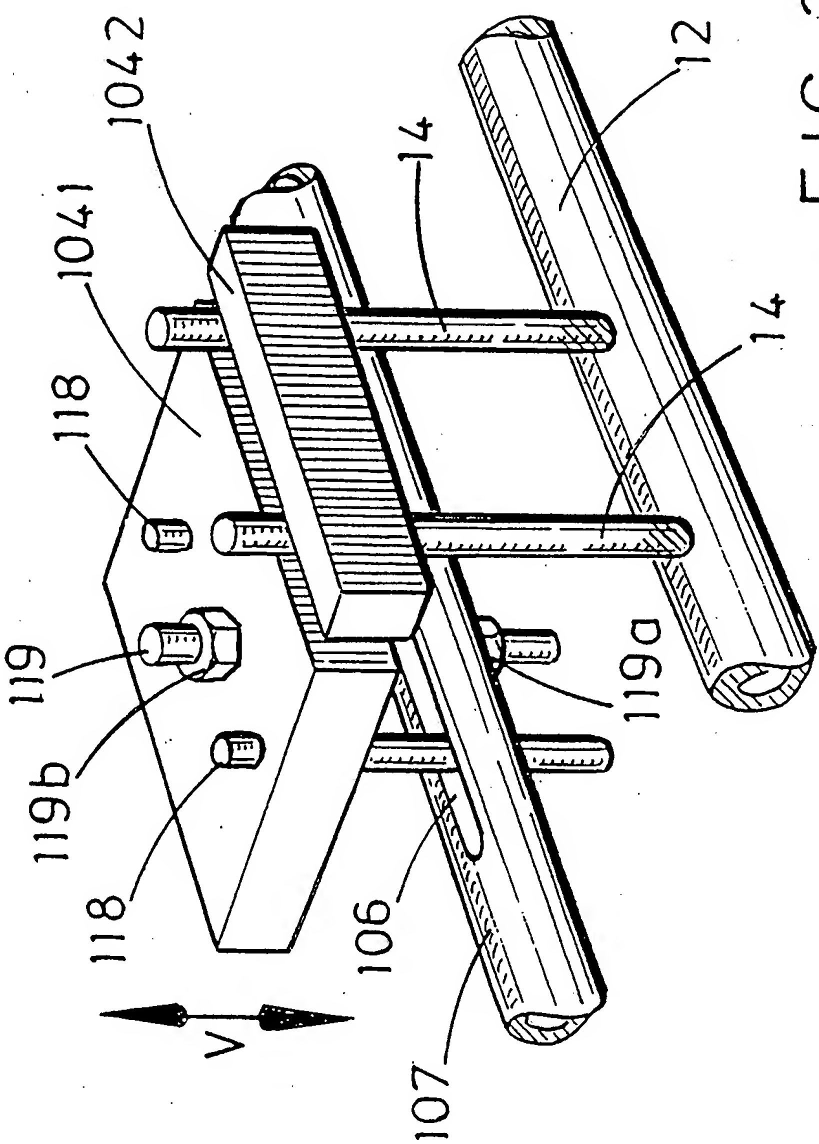
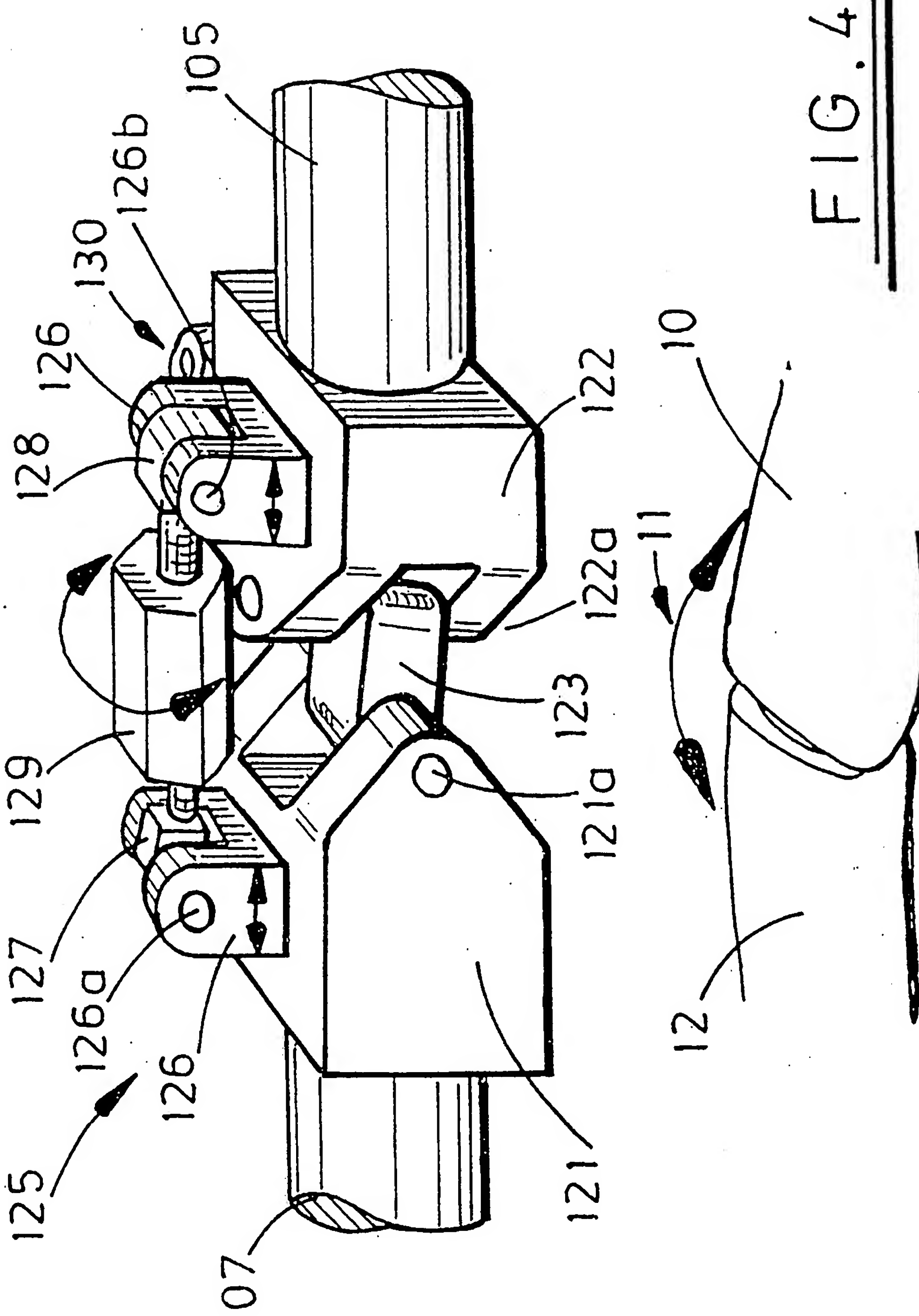


FIG. 3


105
126b
130
126
128
122
122a
11
10
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126a
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121
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107

FIG. 4

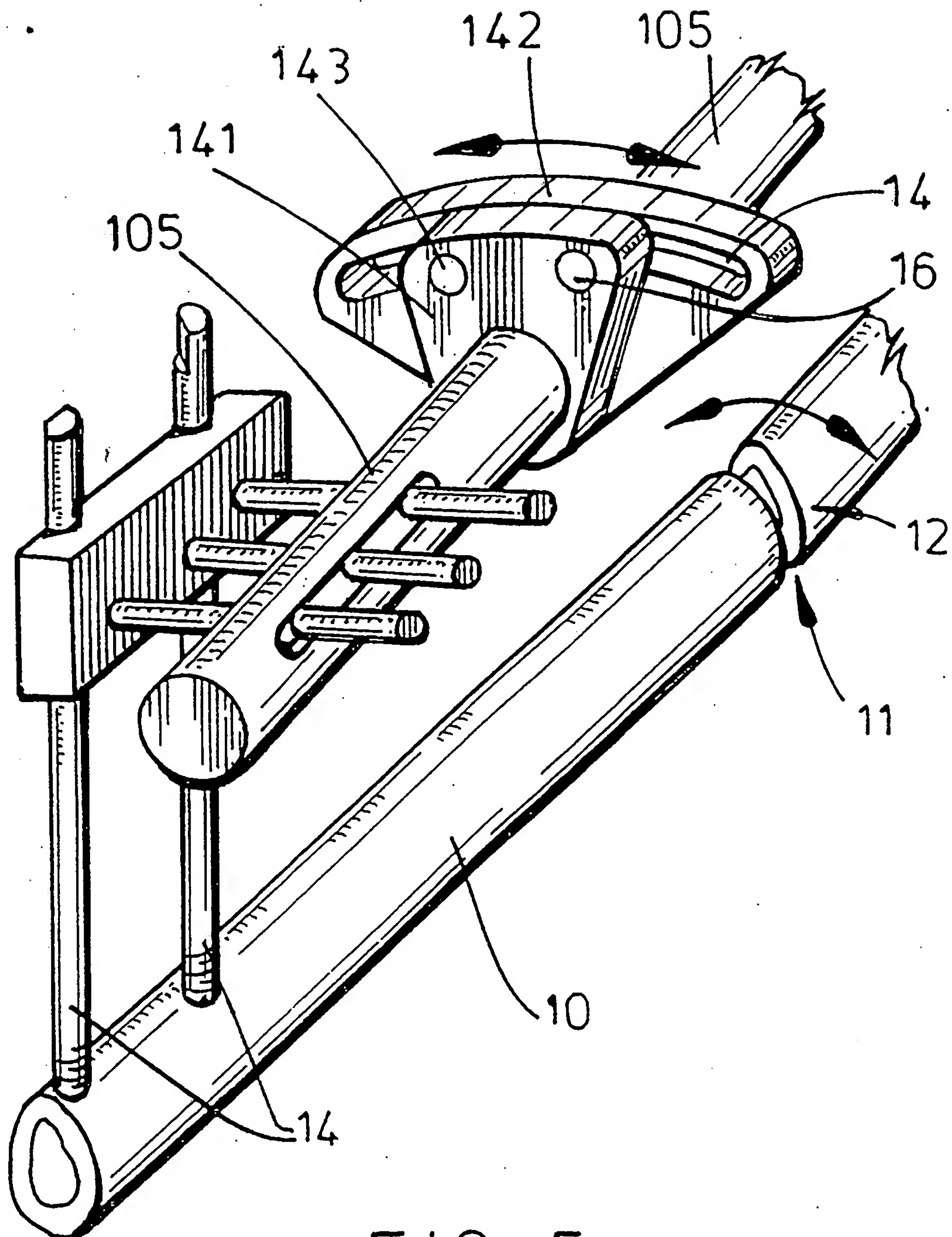
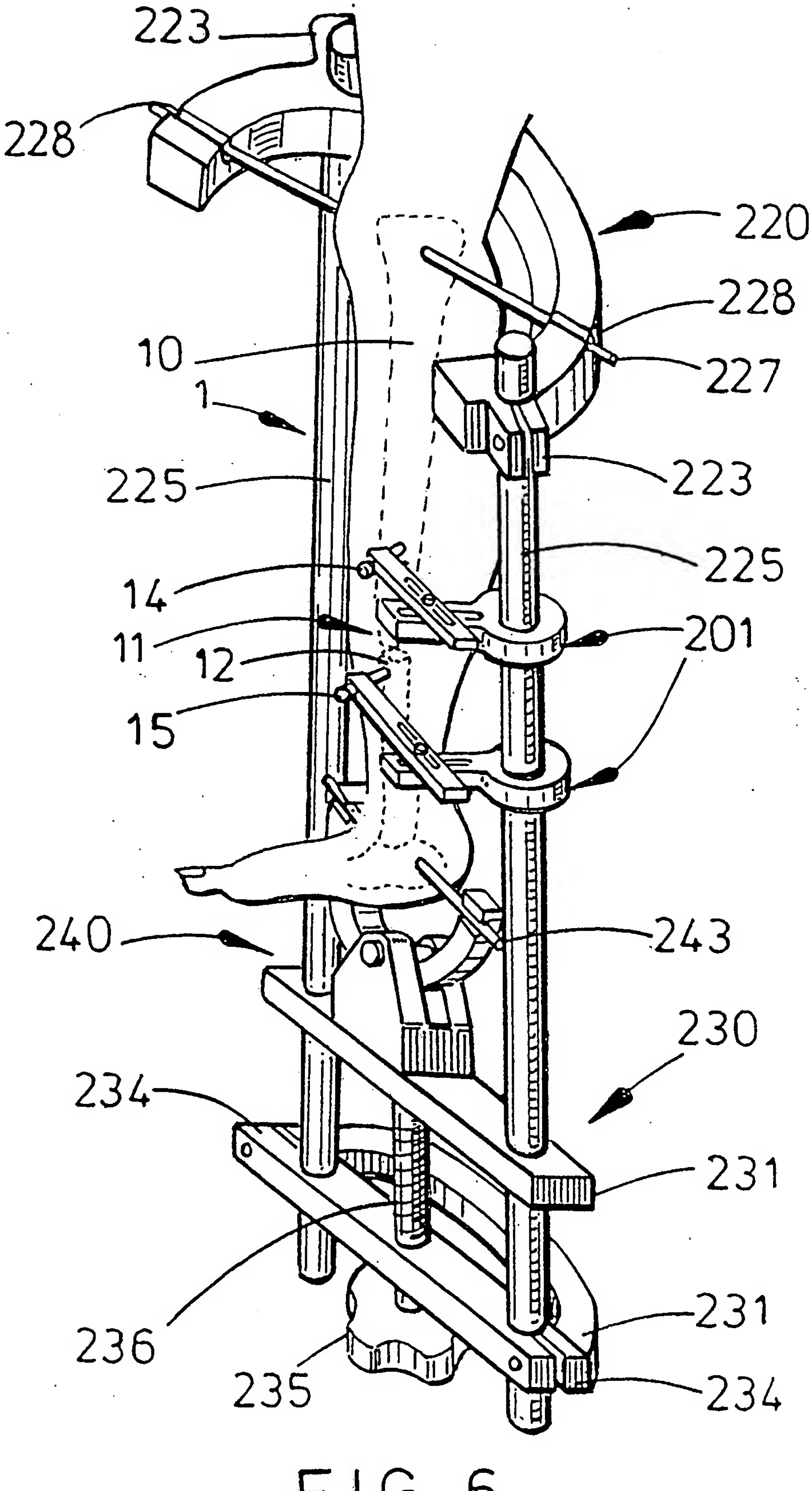


FIG. 5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234

FIG. 6

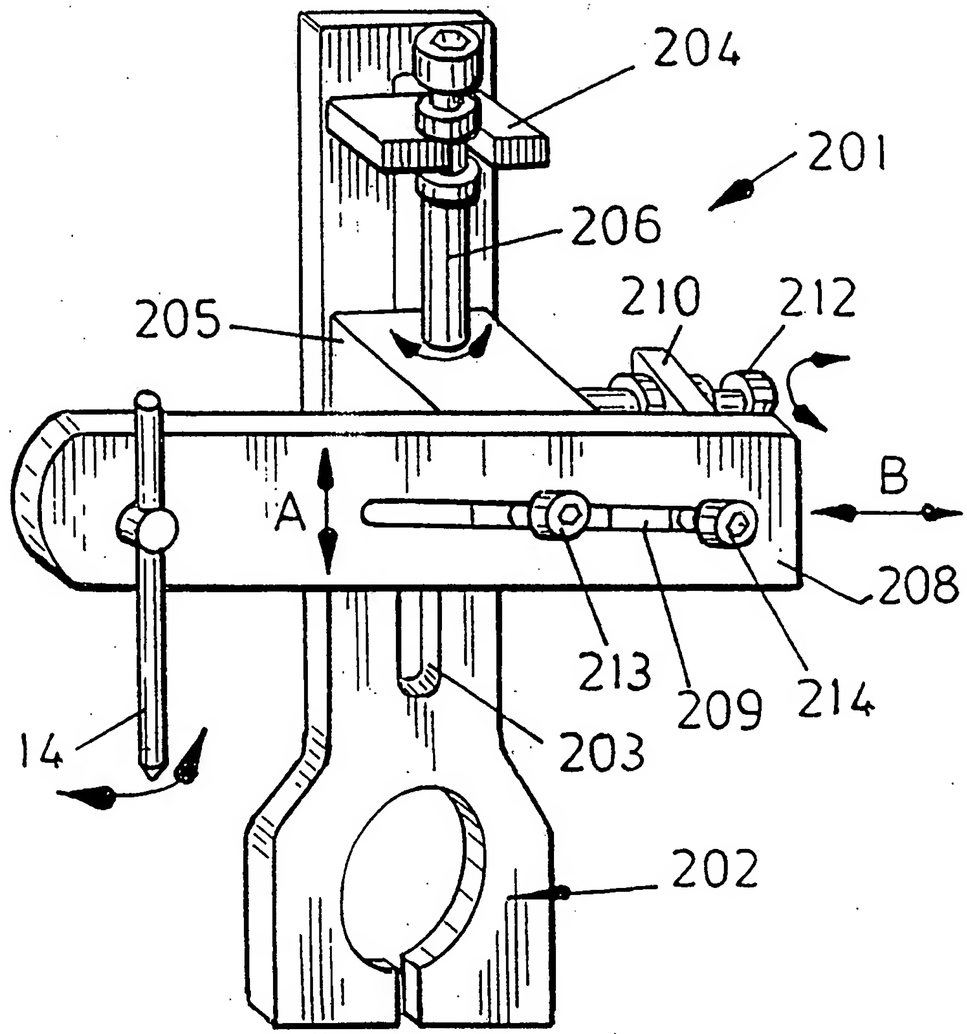


FIG. 7

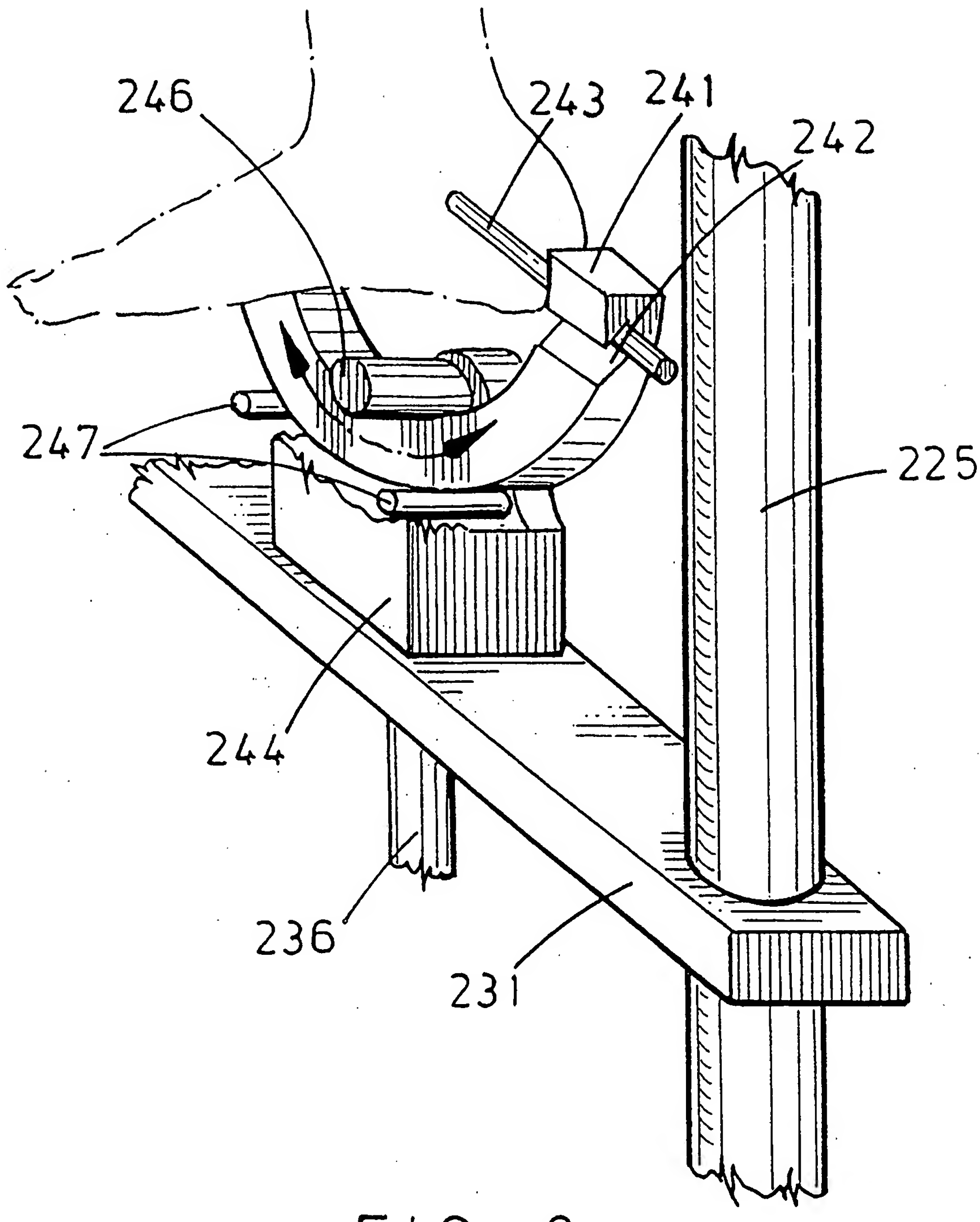


FIG. 8

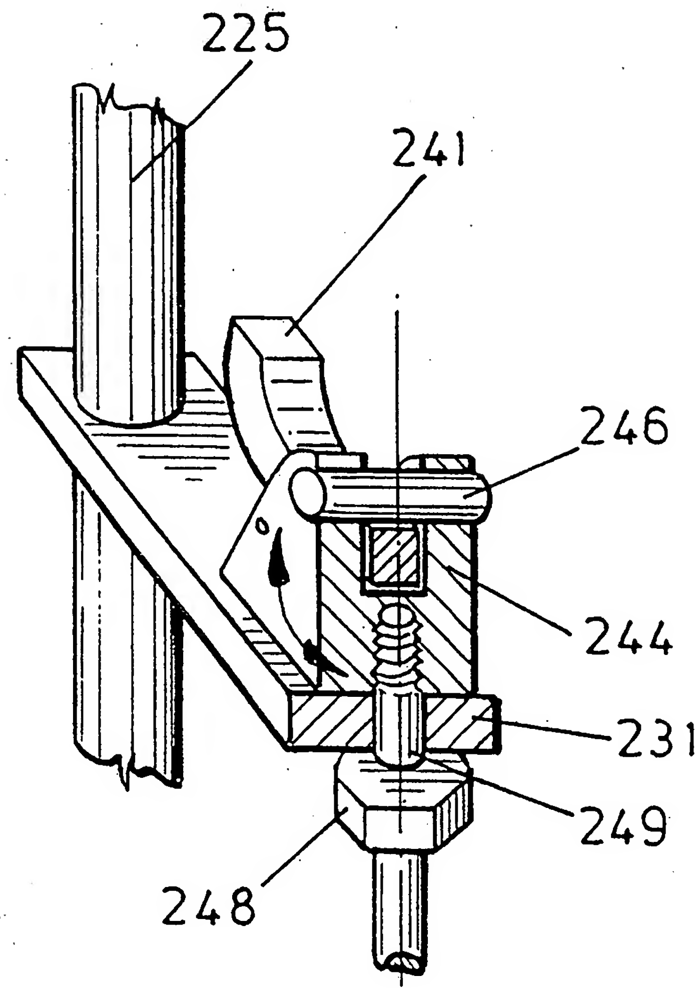


FIG.9

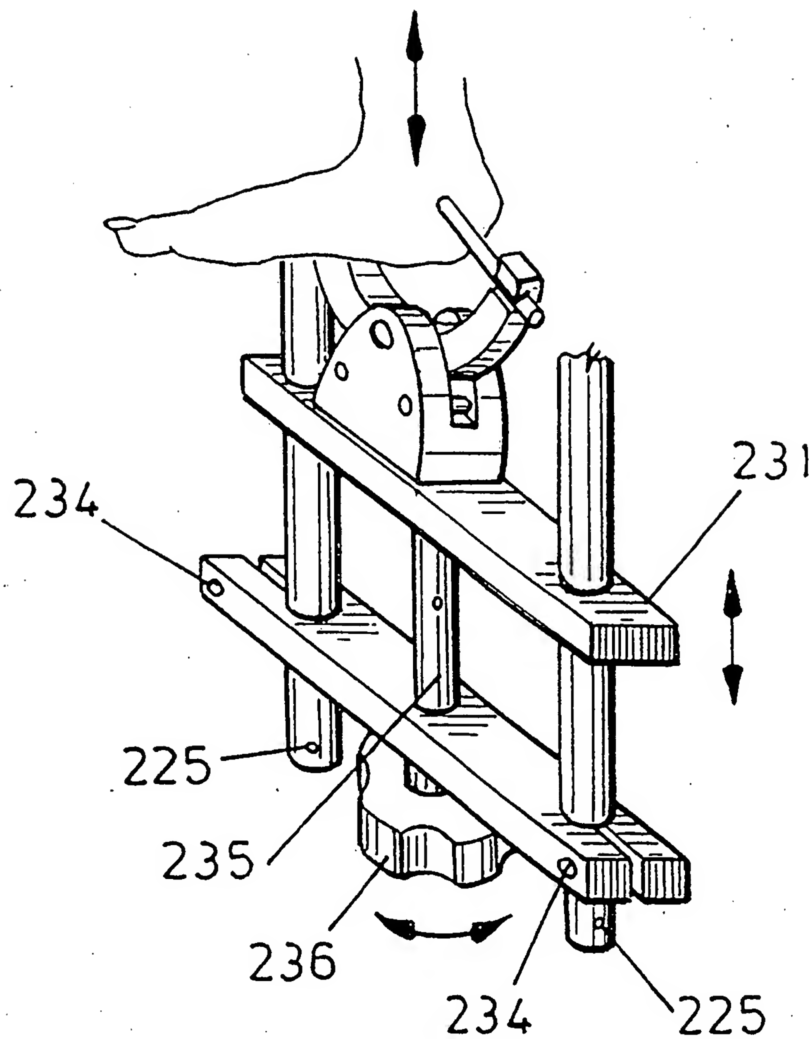


FIG.10

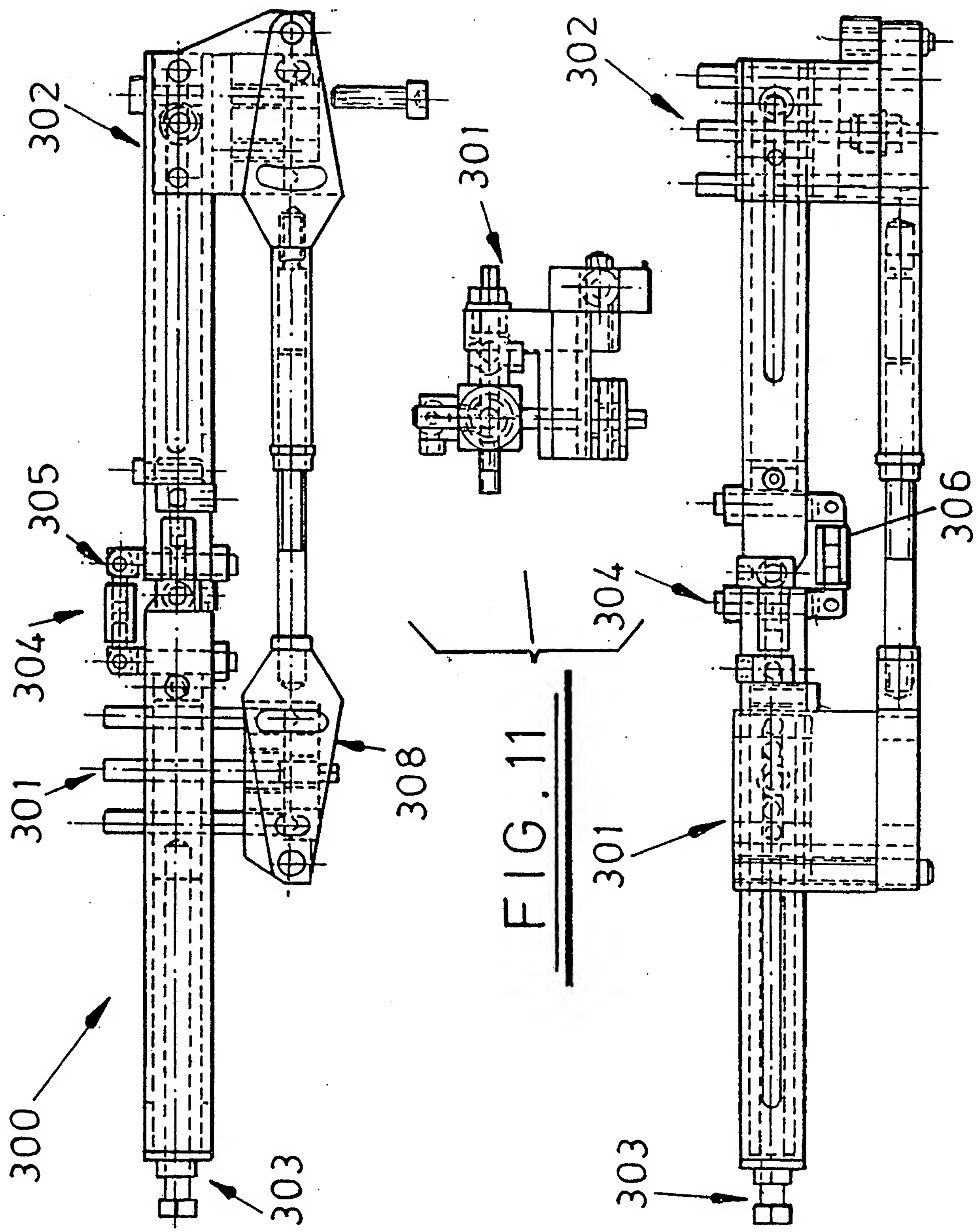


FIG. 11

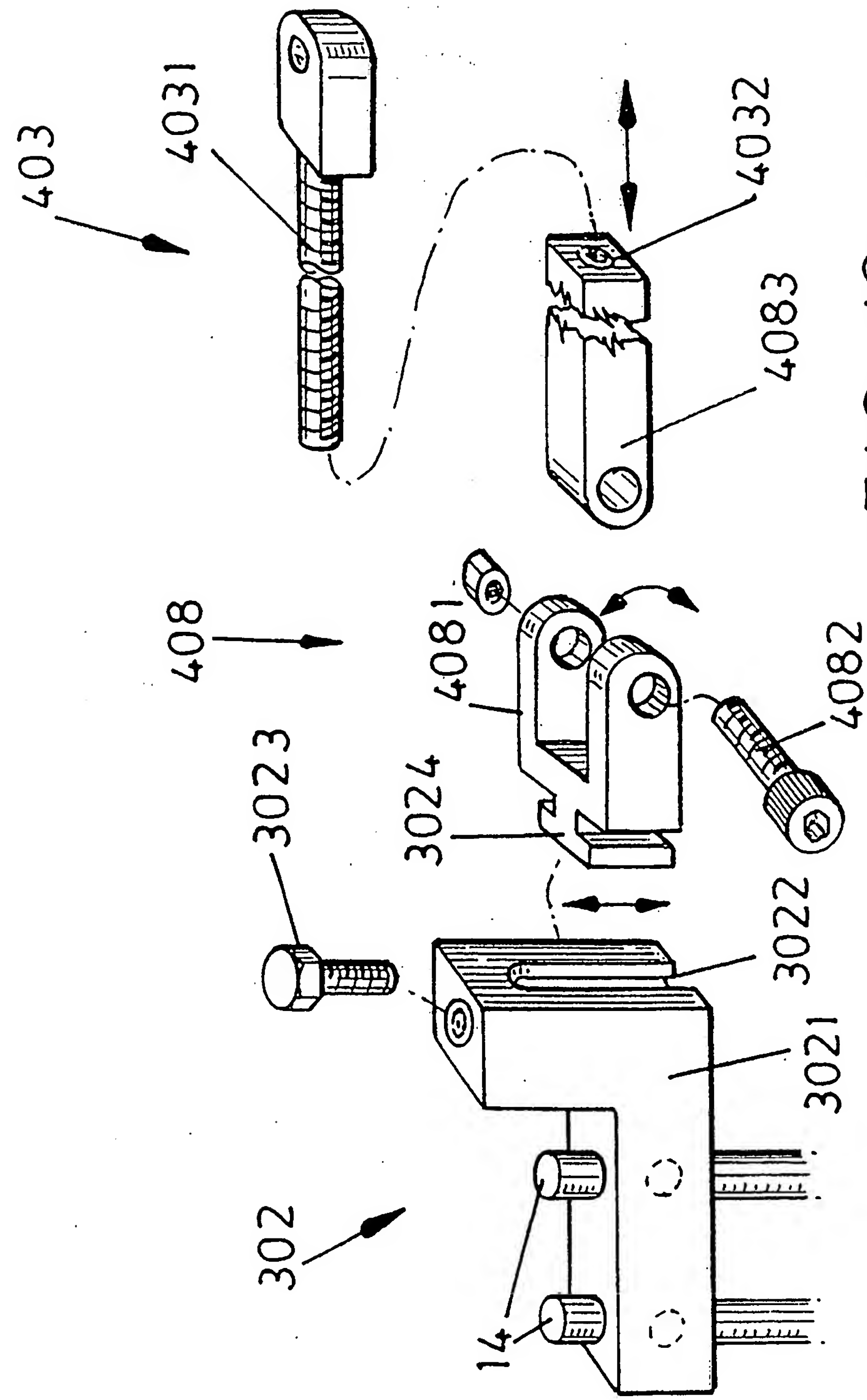
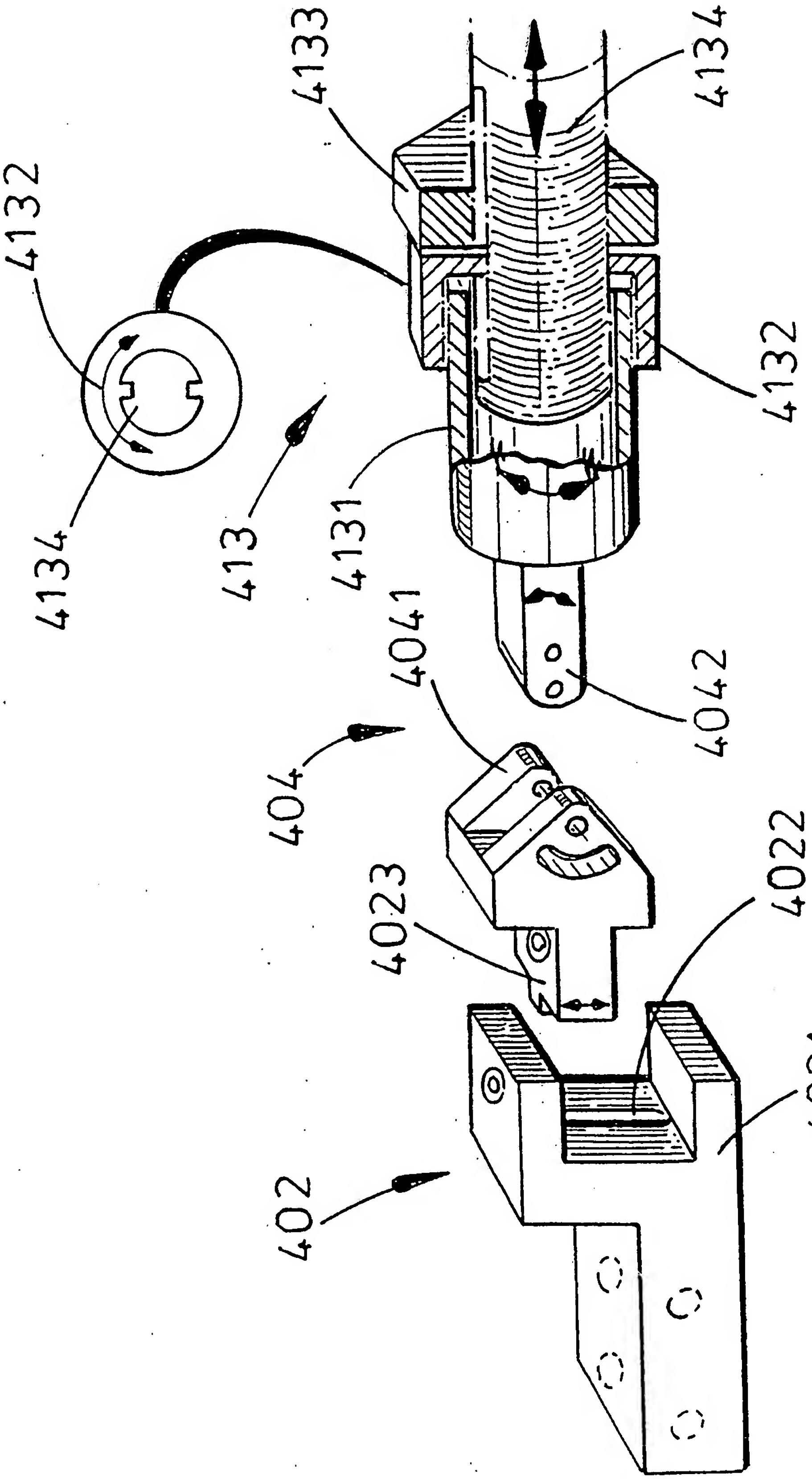


FIG. 12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402

FIG. 13

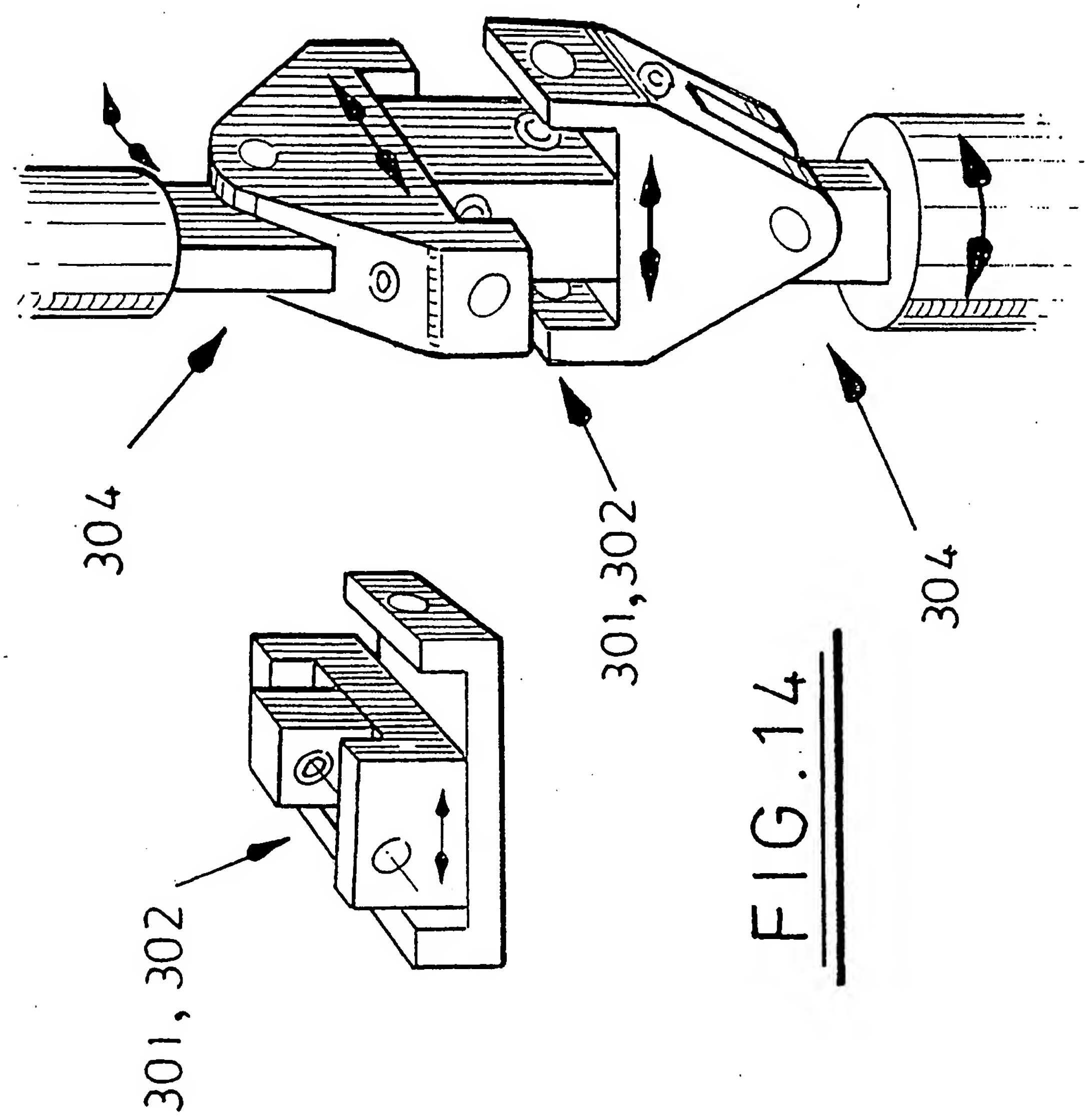

FIG. 14